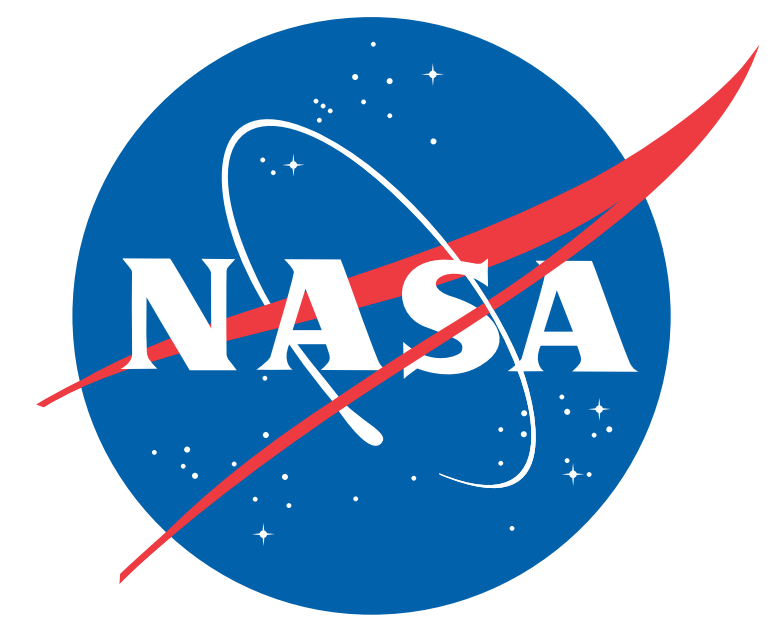




Noninvasive Measurement of Blood Properties Using Doppler Ultrasound



J.G. Myers and P. Parsons-Wingerter, John H. Glenn Research Center,
National Aeronautics and Space Administration, Cleveland, Ohio

J.P. Kizito, W.V. Meyer, N. Daidzic, N. Rashidnia, and C. Davis,

National Center for Space Exploration Research on Fluids and Combustion, Cleveland, Ohio

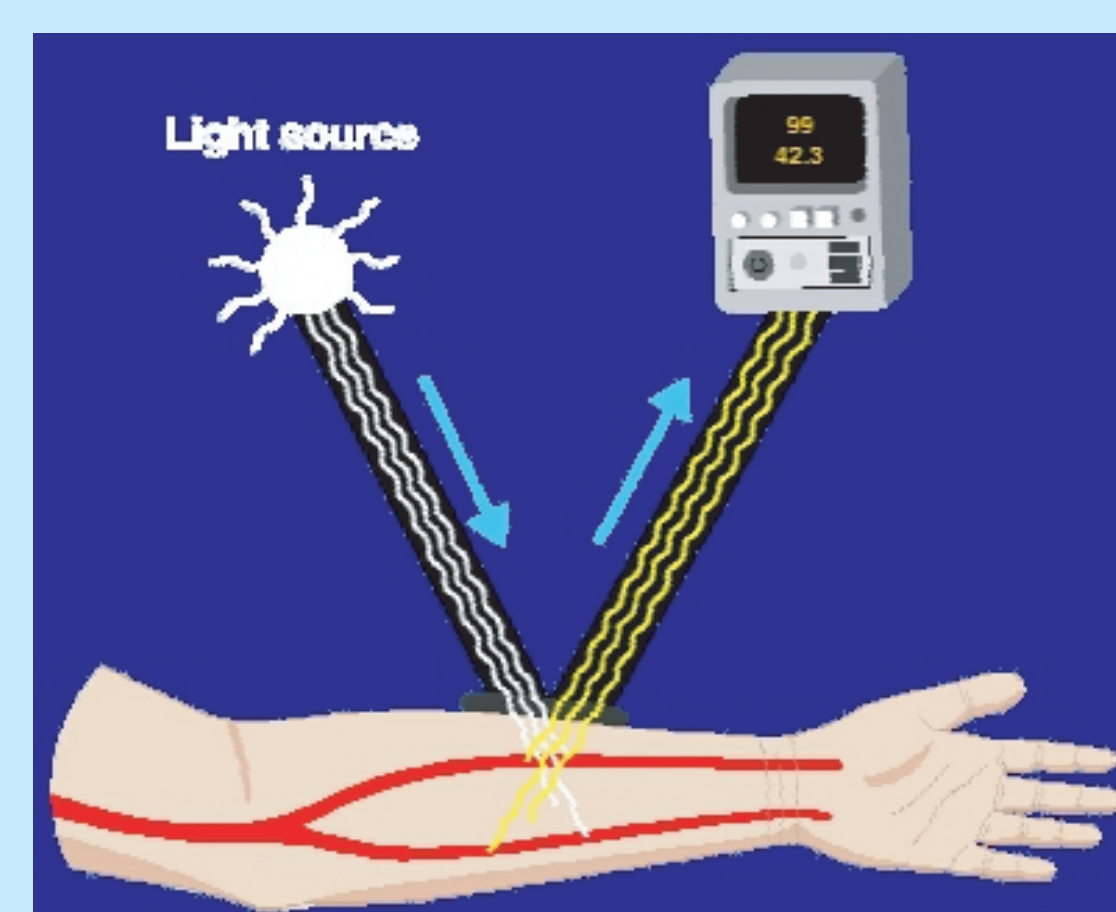
M. Phelan, Department of Emergency Medicine, The Cleveland Clinic Foundation, Cleveland, Ohio

Introduction and Objectives

- Imperative that technologies be developed for in-space evaluation of astronaut health
- Routine noninvasive measurement of blood hematocrit
- Ultrasound system for noninvasive measure and monitor of human blood characteristics for in-space application

Background

- Non-invasive optical methods
- Optical assessment of hemoglobin (in vitro or in vivo through micro-vasculature)
 - Difficult to implement
 - Sensitivity to skin pigmentation (Melanin), which obscures NIRS
 - Sensor placement
 - RBC condition (shape and size)



NIRS system proposed by Zhang et al, Appl. Spectrosc, 54, 294, 2000

Acoustic methods

- Acoustic characteristics vary with hematocrit
- “Backscatter signal” interpretation is complicated by several factors
 - Tissue attenuation
 - Spectral broadening
 - Signal speckle
 - RBC packing factor (fluid dependent)
 - Artery localization
 - Small measurement area

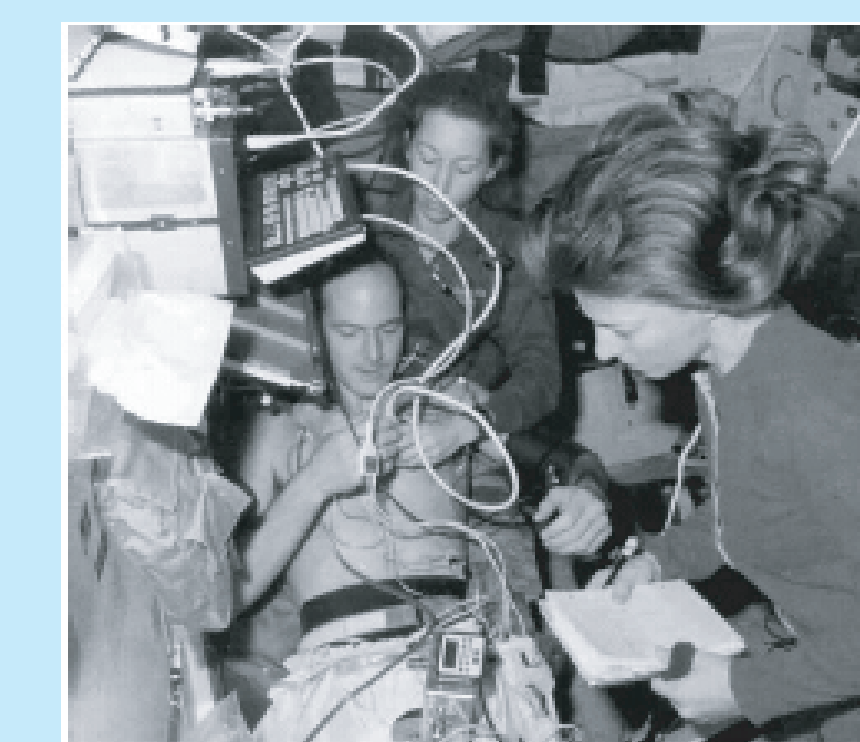
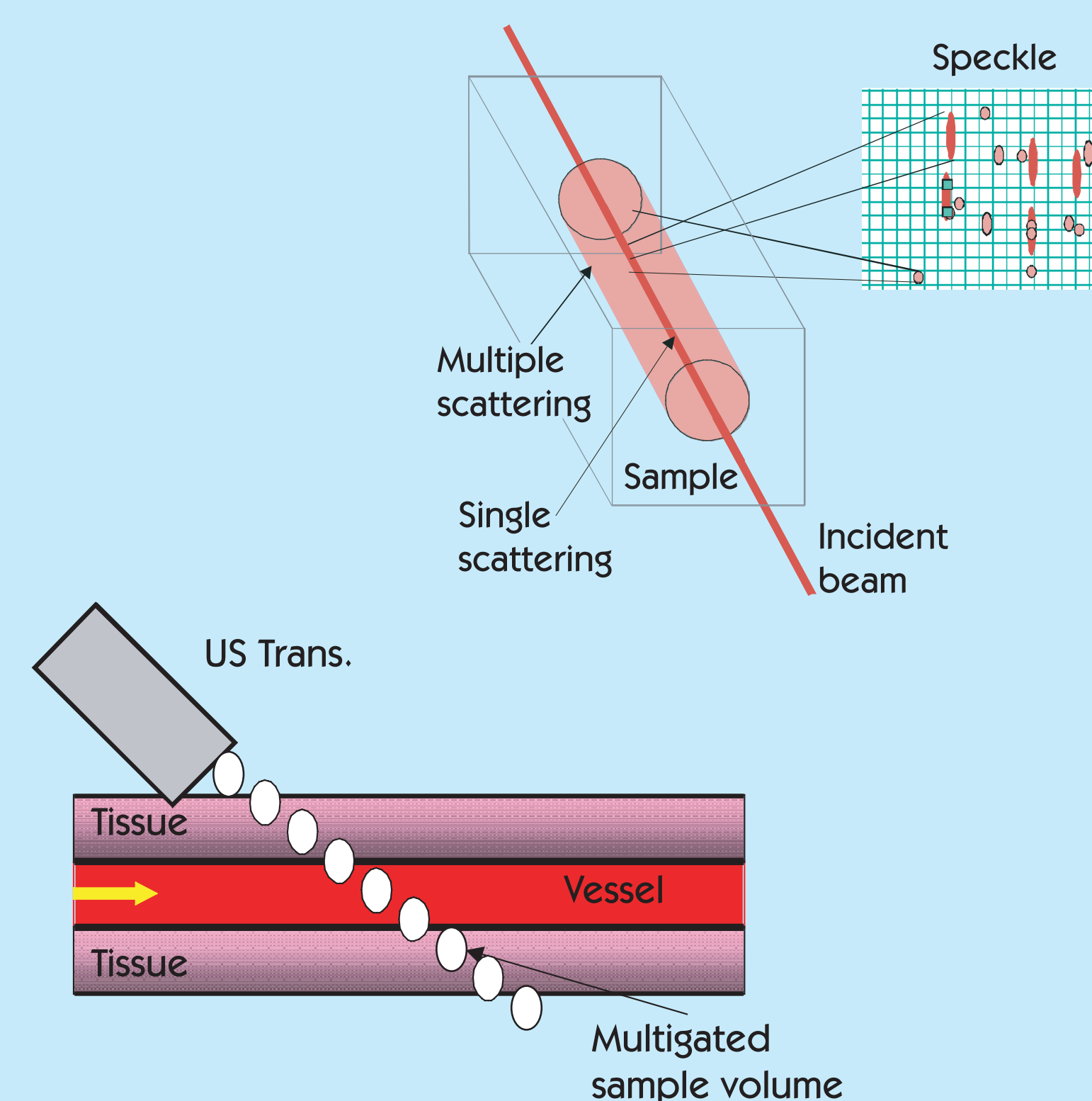


“Soon to be released” www.hemametrics.com

Methods

Acoustic approach by implementing

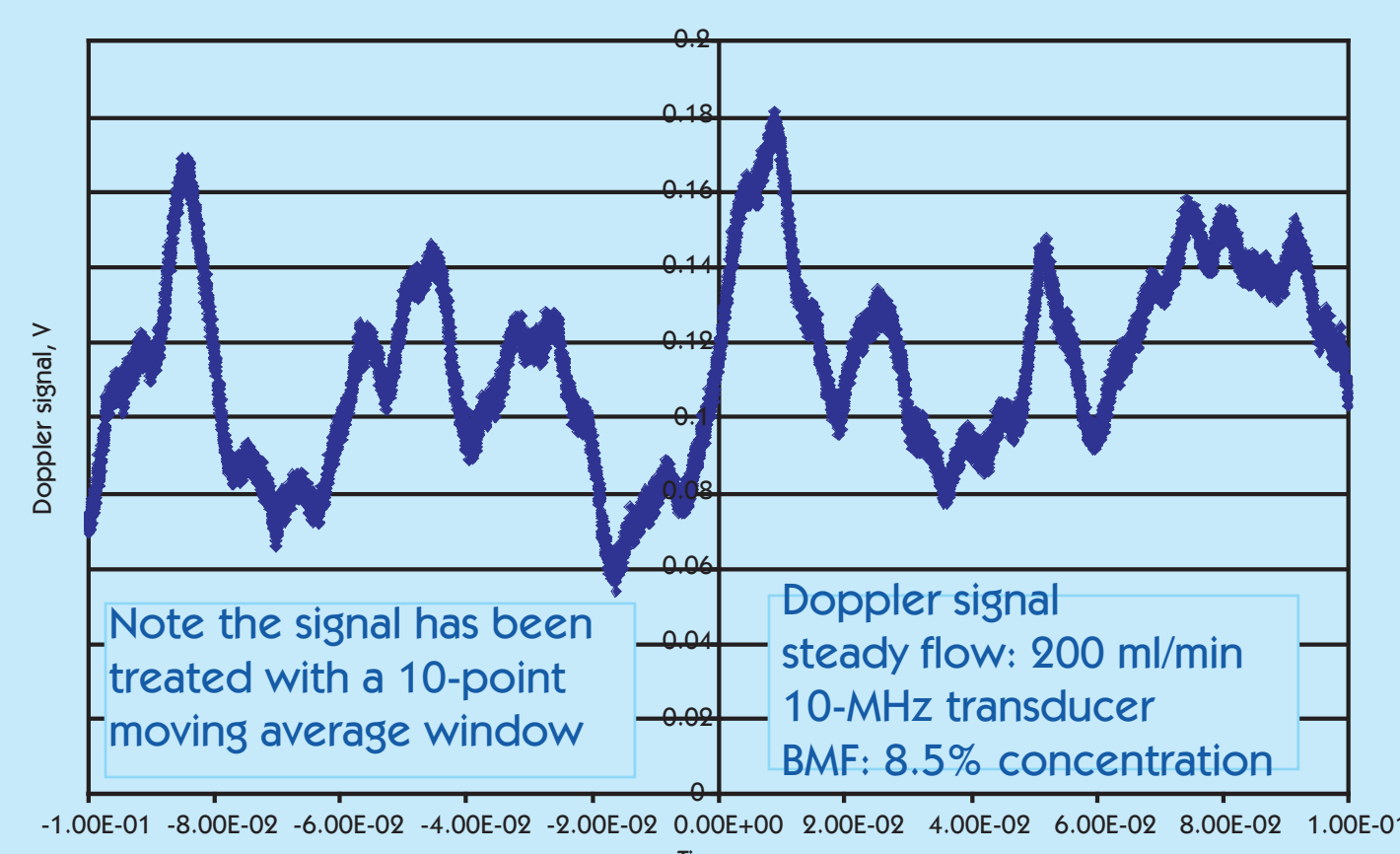
- A Novel multigated doppler system allowing simultaneous measurements across vessel that addresses
 - Mitigation of tissue attenuation
 - Precise artery location
 - Small sample area
- A unique cross-correlation technique to condition the ultrasound signal
 - Addresses spectral broadening and signal speckle
 - Suppress signal degradation from multiple scatters
- Unique combination of in vitro, in vivo, and computational testing
 - Assess system performance
 - Evaluate the significance of RBC packing factor, elucidate sampling locations



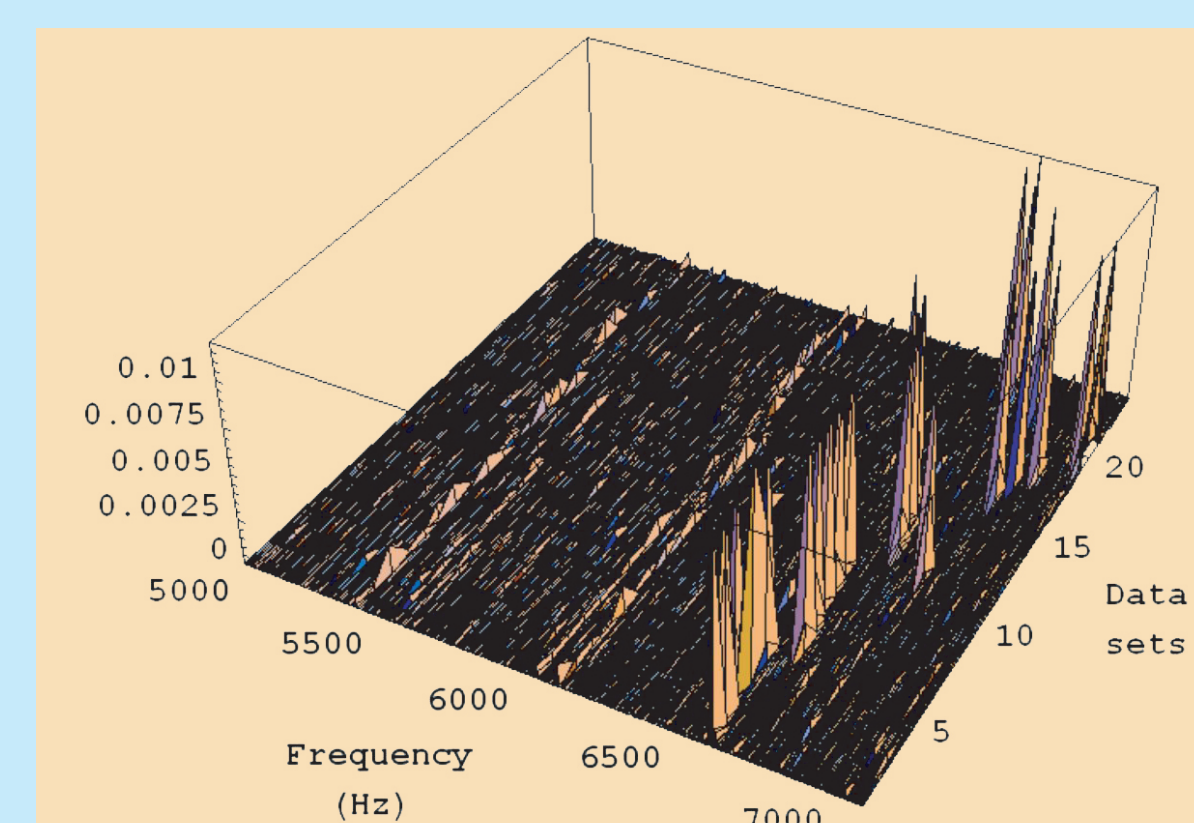
STS-32 crew uses ultrasound for diagnostics

Multigated Doppler system isolates the artery and lumen with minimal user input. Novel cross correlation approach originally developed for the optical assessment of Colloidal suspensions improves signal. Innovative in vitro, in vivo, and computational techniques to model the blood ultrasound dynamic interaction will allow specific characterization backscatter signal features.

Preliminary Results



Doppler signal acquired at steady flow (200 ml/min) using a 10 MHz transducer and BMF at 8.5 percent concentration.



Correlation of Doppler power spectrum for flow rates between 50 and 200 ml/min using model blood fluids with hematocrits of 2 to 10 percent.

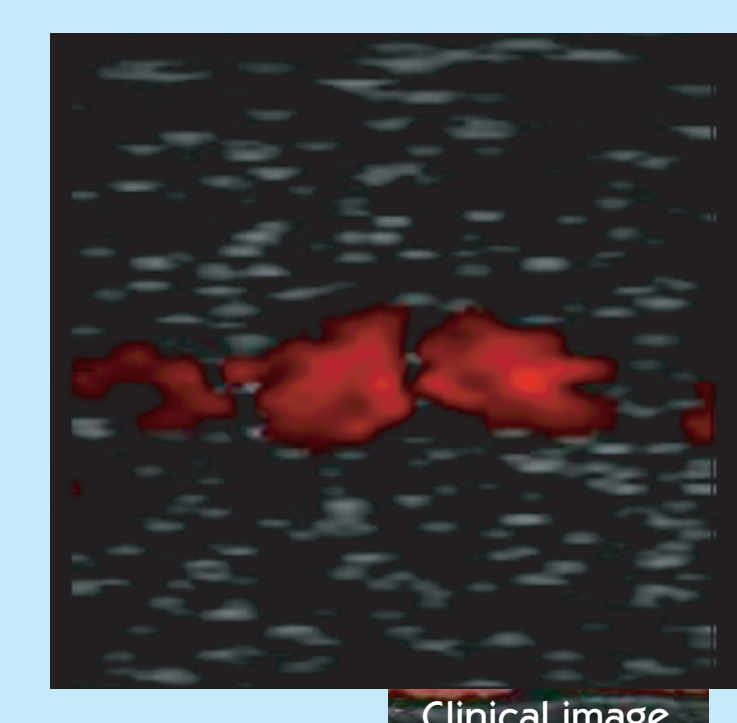
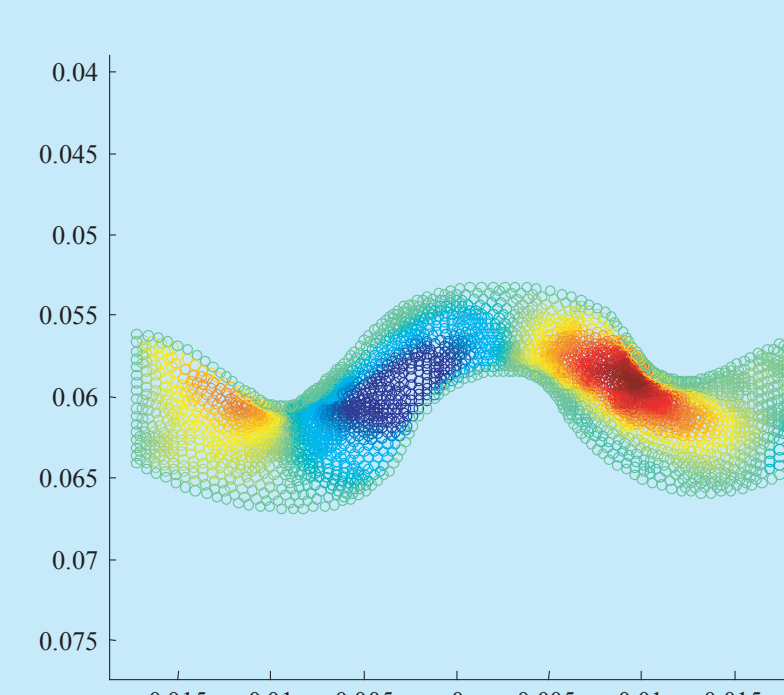
Conclusions

Successfully completed construction of an ultrasound test facility that includes Doppler ultrasound system, RF ultrasound system, Hydrophone, high-speed DAQ, tissue-mimicking phantom, and blood-mimicking fluid capabilities

Significance and technical merit

1. First universal noninvasive characterization of blood and plasma products
2. Advance in ultrasound system performance
 - Provides clinically acceptable readings, regardless of patient parameters
 - Improvements to ultrasound backscatter signals during in vivo measurements could be easily extended to the improvement of two- and three-dimensional imaging modalities

CFD solutions used to interpret Doppler signals



Acknowledgments

